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Analysis and Design of Low Cost Multi Stored Building Using Staad Pro

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Abstract - *This paper aims to point out the various aspects of prefabricated building methodologies for low cost school building by highlighting the different types of prefabrication techniques, and the economical advantages achieved by its adoption. In a building the foundation, walls, doors and windows, floors and roofs are the most important components, which can be analyzed individually based on the needs thus, improving the speed of construction and reducing the construction cost. The major current methods of construction systems considered here are namely, structural block walls, mortar less block walls, prefabricated roofing components like precast RC planks, precast hollow concrete panels, precast concrete/Ferro cement panels are considered.low cost school building design using Staad pro vi8*

Key Words: Prefabrication; Precast RCC , precast joist, Ferro cement products ,Staad pro vi8

1. INTRODUCTION

Affordable housing is a term used to describe dwelling units whose total housing cost are deemed "Affordable" to a group of people within a specified income range. In India, the technology to be adopted for housing components should be such that the production and erection technology be adjusted to suite the level of skills and handling facilities available under metropolitan, urban and rural conditions.

1.1 Logical approach for optimizing housing solutions

There should be logical steps regarding providing suitable technology given a set of available choices as analyzed from its technical and economical view.

1. Optimum utilization space in the design which deals with efficient utilization space in the structure; space circulating in it.

2. It should have an economy approach during individual design, layout or in various clusters.

3. While preparing the specifications it should be kept in mind that, cost effective construction systems are adopted.

4. Energy efficiency has gained considerable importance due to energy crisis especially in developing countries. Orientation, built–form, openings & materials play a vital role besides landscaping/ outdoor environment.

5. To develop an effective mechanism for providing appropriate technology based shelter particularly to the vulnerable group and economically weaker section.(R.K.Garg,2008)

1.2 Prefabrication as applied to Low School Building:

(P.K.Adlakha and H.C.Puri, 2002) The advantages of prefabrication are:

1. In prefabricated construction, as the components are readymade, self-supporting, shuttering and scaffolding is eliminated with a saving in shuttering cost.
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2. The shuttering gets damaged owing to frequent use in conventional methods of concrete construction, because the process involves repeated cutting nailing etc. On the contrary, the mould can be used for large numbers of repetitions with the precost components thus reducing cost per unit of mould.
3. Time in the prefabricated housing system is saved as it uses precast elements, which are cast off-site during the period foundations are being laid, while finishes and services could be done below the slab right away. In a traditional in-situ RCC slab, work cannot be executed as it is obstructed by props and shuttering till they are withdrawn. Thus, the time saving is due to saving of money.
4. In precast construction, similar types of components are produced repeatedly, which increases the productivity and economy in cost too.
5. As there is repeated production of similar types of components in precast construction, therefore, it results in faster execution, more productivity and economy.
6. In prefabricated construction, the work at site is reduced to minimum, which enhances the quality of work, reliability and cleanliness.
7. Execution is much faster than the conventional methods, thereby reducing the time period of construction which can be beneficial in early returns of the investment.

Concept of prefabrication / partial prefabrication has been adopted for speedier construction, better quality components & saving in material quantities & costs. Some of these

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2. LITERATURE REVIEW

The demand for low-cost housing is steadily rising due to rapid urbanization and increasing population. To address this, structural engineers and researchers have focused on the application of cost-effective design techniques and software tools like STAAD Pro to optimize construction costs without compromising safety and functionality. This literature review explores key research and developments in this area..

2.1 Overview of STAAD PRO in structural analysis and design

STAAD Pro is a structural analysis and design software widely used for modeling, analysis, and design of structures. It supports different building codes and materials, such as reinforced concrete, steel, and composite structures. Several studies highlighted its efficiency in:

Finite Element Analysis (FEA): Structural behavior can be simulated under various loads.

Cost Optimization: Optimized design techniques reduce the usage of material.

Time Efficiency: Saves design and analysis time compared to manual calculations.

2.1 Low-Cost Housing Design and Consideration

Designing low-cost multi-storey buildings requires balancing functionality, safety, and affordability. Key considerations include:
Material Selection: Utilization of locally available materials and sustainable options such as fly ash bricks, recycled aggregates, and lightweight concrete.
Structural Efficiency: Employing effective load distribution techniques and minimalist design approaches.
Foundation Design: Exploring cost-effective foundations like isolated footings or combined footings depending on soil conditions.

2.2 Role of STAAD PRO in Cost Optimization

From research, it is evident that STAAD Pro saves in the construction process through:
Optimized structural elements: If stress distribution is analyzed and beam-column sizes are optimized, minimum material usage can be possible.
Load Combinations: Analysis by wind, seismic, and live loads can ensure safety without overdesigning the structure.
Iterative Design Process: The software allows for multiple design iterations to realize the best balance between cost and safety possible.

2.3 Case Studies

1. Residential Buildings in Developing Countries Experiments in countries such as India and Bangladesh have been conducted to prove that through the use of STAAD Pro, design time can be saved by 40-50%, with material savings ranging from 10-20% compared to traditional designs. Researchers highlighted the usage of low-cost materials such as fly ash and recycled steel.

2. Low-Cost Structures-Seismic Design

Researchers have found that STAAD Pro could be used to design a multi-storey building in earthquake-prone areas. Following IS 1893:2016 and Eurocodes, they produced cost-effective designs that were aligned with seismic safety standards.

3. Use of Alternative Materials

Analysis on alternative materials such as bamboo-reinforced concrete and geopolymer concrete using STAAD Pro has been promising in reducing total costs.

5. Challenges in Low-Cost Building Design

Data Accuracy: Quality of outputs depends on the correct input parameters for material properties and load data.

Highly Trained Manpower: Design with sophisticated software can only be done with high-income regions as it demands a good degree of training, which can be lacking in low-income regions.

Alternative material durability: Long-term sustainability of such alternatives is another aspect to consider.

2.4 Future Research Directions

Integration of BIM with STAAD Pro: How Building Information Modeling (BIM) Can Improve Cost Estimation.
AI and Optimization Algorithms: Implement artificial intelligence and genetic algorithms to further enhance the optimization of structural designs.
Sustainability Metrics: Use life-cycle analysis to present long-term savings.

3. LOADS CONSIDERED

3.1Dead Loads

All permanent constructions of the structure form the dead loads. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads may be calculated from the dimensions of various members and their unit weights. the unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 kN/m" and 25 kN/m" respectively.

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3.2 Imposed Loads

Imposed load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. Imposed loads do not include loads due to wind, seismic activity, snow, and loads imposed due to temperature changes to which the structure will be subjected to, creep and shrinkage of the structure, the differential settlements to which the structure may undergo.

3.3 Wind Loads

Wind is air in motion relative to the surface of the earth. The primary cause of wind is traced to earth's rotation and differences in terrestrial radiation. The radiation effects are primarily responsible for convection either upwards or downwards. The wind generally blows horizontal to the ground at high wind speeds. Since vertical components of atmospheric motion are relatively small, the term 'wind' denotes almost exclusively the horizontal wind, vertical winds are always identified as such. The wind speeds are assessed with the aid of anemometers or anemographs which are installed at meteorological observatories at heights generally varying from 10 to 30 metres above ground.

3.4 Pressure coefficient

Wind is moving air in relation to the earth's surface. The main reason why wind exists is due to the rotation of the earth and inequality in terrestrial radiation. The latter is the cause of convection which is upward or downward. Generally, at high wind speed, the wind blows horizontal to the ground. Since vertical components of atmospheric motion are relatively small, the term 'wind' denotes almost exclusively the horizontal wind, vertical winds are always identified as such. The wind speeds are assessed with the aid of anemometers or anemographs which are installed at meteorological observatories at heights generally varying from 10 to 30 metres above ground.

3.5 Topography

The basic wind speed Vb takes into account the general level of siteabove sea level. This does not allow for local topographic features such as hills, valleys, cliffs, escarpments, or ridges that may significantly influence wind speed in their area. The effect of topography is to accelerate wind near the summits of hills or crests of cliffs, escarpments or ridges and decelerate the wind in valleys or near the foot of cliff, steep escarpment, or ridges.

4. DESIGN CRITERIA

4.1 Materials

The structure is with conventional reinforced concrete. Hereunder are the requirements of the building: Concrete: Grade of concrete is as follows: Foundation: Pile/open M35 fck=35N/mm2 Walls and Columns: M40/M35/M30 fck=40/35/30 N/mm2
Beams & Slabs: M25, fck=25N/mm2
Reinforcement: Yield strength of 500 N/mm2 (TMTbars).

4.2 Fire Requirements

A minimum two hours fire rating is adopted for members i.e., Slabs, beams, columns and wall Nominal cover to the reinforcements is:
IS 456 Table 16A

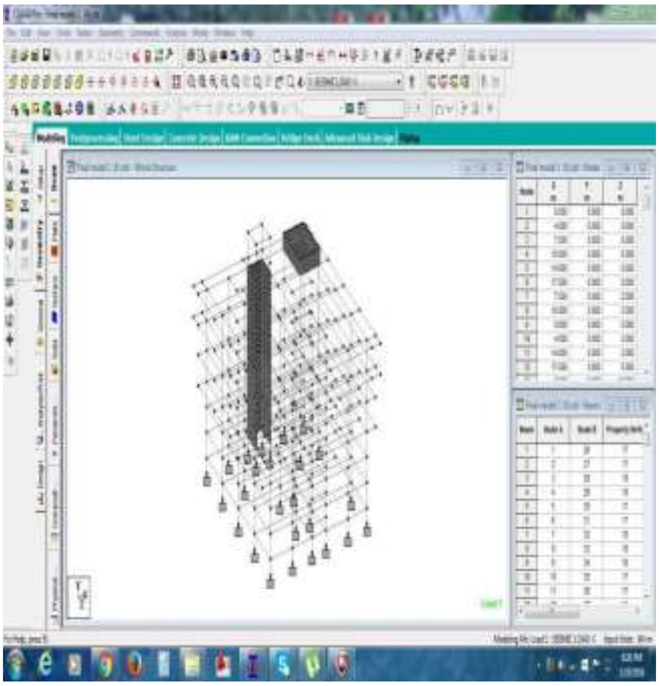
Beams: Simply supported	40 mm
Continuous	30 mm
Slabs: Simply supported	35 mm
Continous	25 mm
Columns:	40 mm
Walls:	40 mm

4.3 Wall loads per meter Height, per meter Length

200mm thick Masonry wall:
Self weight of wall: 3.60kN/m2
Total thickness of plaster: 0.035m
(Including inside 15 mm + outside 20 mm)
Weight of plaster: 0.035 x 20.40=0.71 kN/m2
Total load: 4.314kN/m2 Say 4.35kN/m2
150mm thick Masonry wall:

Self weight of wall= 2.70kN/m2
Total thickness of plaster: 0.035m
(Including inside 15 mm + outside 20 mm)
Weight of plaster: 0.035 x 20.40=0.71 kN/m2
Total load: 3.41tkN/m2 Say 3.45tkN/m2
100mm thick Masonry wall:
Self weight of wall: = 1.80kN/m2
Total thickness of plaster: 0.035m

5. Analysis of G + 10 RCC Framed Building using STAAD PRO



5.1 FIG. Elevation of the Low Cost Multi Stored Building

5.2 Generation of member property

By the use of a window, the above generation can be carried out in STAAD.Pro. In the following section, it is being taken for beams and has dimensions as 0.6 * 0.3 m, while for the column it is taken 0.5 * 0.5 m on ground floor, and the dimension at the remaining top floors, the same has been shown at 0.5 * 0.5 m.

5.3 Dead load from Slab

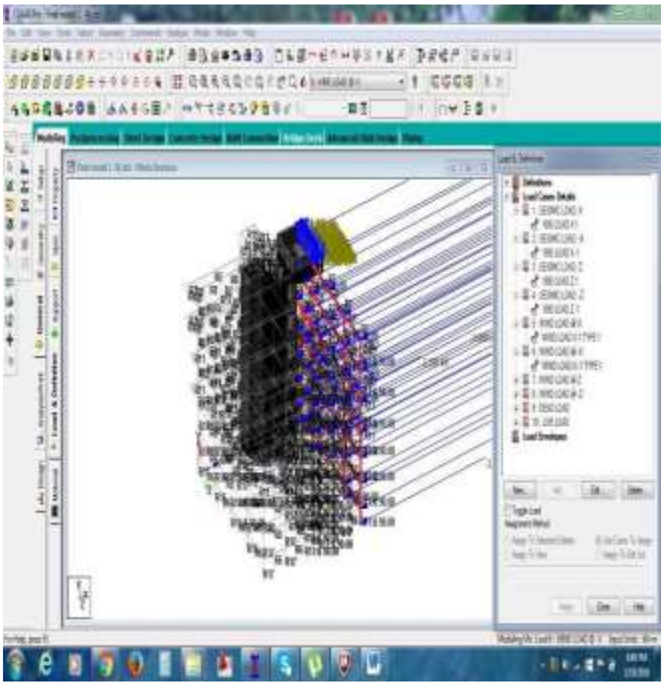
Dead load from the slab can also be created in STAAD.Pro with floor thickness and load on floor per sq m. For load per sq m, following is the calculation: weight of beam, weight of column, weight of RCC slab, weight of terracing, external walls, internal walls and parapet over roof.

5.4 Live load

The live load considered in each floor was 4 KN/sq m and for the terrace level it was considered to be 1.5 KN/sq m. The live loads were generated in a similar manner as done in the earlier case for dead load in each floor. This may be done from the member load button from the load case column.

5.5 Wind load

The software generated its own wind load values, following IS 875. In the define load command section, in the category of wind load, definition of wind load was given. The wind intensities at different heights were manually calculated and fed to the software. Following those values it generated the wind load at various floors.



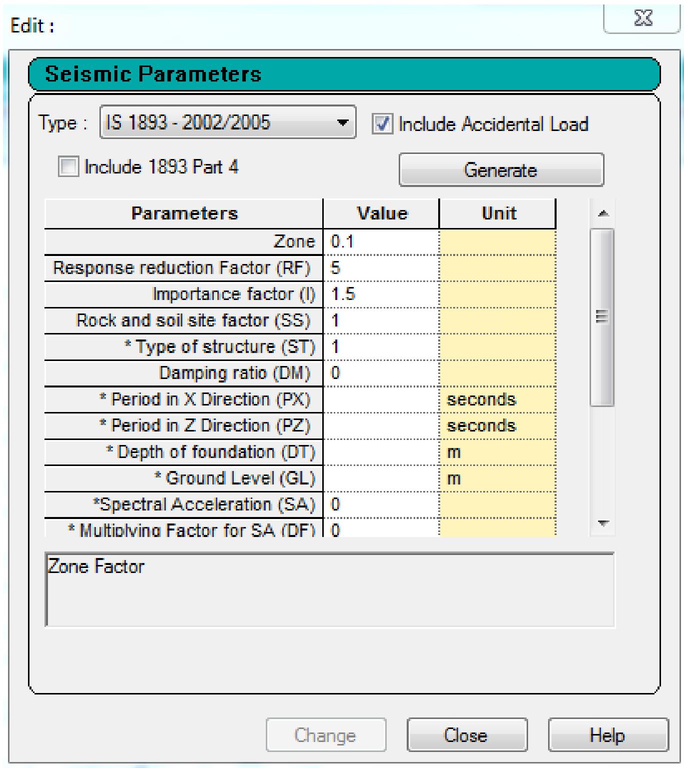
5.6 Seismic load

The seismic load values were computed based on IS 1893-2002. STAAD.Pro has a seismic load generator as per the IS code cited above.

Description:

The seismic load generator is used to generate lateral loads in the X and Z directions only. Y is the direction of gravity loads. This facility has not been developed for cases where the Z axis is set to be the vertical direction using the "SET Z UP" command.
Methodology
The design base shear is computed by STAAD as per IS: 1893(Part 1)-2002.
V = Ah*W

Where, Ah = (Z*I*Sa)/ (2*R*g)



CONCLUSION:

Low cost school building targets can be achieved by replacing the conventional methods of planning and executing building operation based on special and individual needs and accepting common denominator based on surveys, population needs, and rational use of materials and resources. Adoption of any alternative technology on large scale needs a guaranteed market to function and this cannot be established unless the product is effective and economical. Partial prefabrication is an approach towards the above operation under controlled conditions. The essence lies in the systematic approach in building methodology and not necessarily particular construction type or design. The methodology for low cost housing has to be of intermediate type- less sophisticated involving less capital investment. (P.K.Adlakha and H.C.Puri, 2002)

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It can calculate the reinforcement required for any concrete section. The program has parameters, which are designed according to IS: 456 (2000). Beams are designed for torsion, shear, and flexure.